

VEHICLE DOOR FOR CAR AND TRUCK

CROSS REFERENCE TO RELATED APPLICATIONS

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- 5 This is a continuation-in-part application of co-pending international application number PCT/DE 96/02120 filed Nov. 7, 1996 and claiming the priority of DE 19543706 A1 filed Nov. 17, 1995 and the amendments filed April 8 and 25, 1997.

BACKGROUND OF THE INVENTION

10 1. Field of the Invention:

The present invention relates generally to vehicle doors, more particularly, to window-guide elements in co-operation with clamping means of the vehicle parts (see definition) in order to properly engage all series-connected doors with the vehicle roof and side rail (sill portion) disposed along the vehicle floor, all post sections (pillar portions) and the transition regions of passenger compartment in the event of arbitrary collision (front, side or lateral, rear collision and/or rollover (overturn)), thereby protecting the passengers against ejection from the passenger compartment and substantially enhancing the survival chance and vehicular stiffness.

2. Description of the Related Art:

20 It is known in the prior art to provide clamping means (engaging means) to engage and to clamp the vehicle doors with the other vehicle parts, thus enhancing the stiffness of vehicle side under load of the side impact force. The abbreviations DE and EP denote the German Pat. Appl. or Doc. and European Pat. Appl. or Doc., which will be omitted hereinafter. However, all these conventional configurations do not take into account the failure of passenger protection due to disengagement (release) of the clamping means in the event of arbitrary side collision, as disclosed by the newspaper Wiesbadener Kurier of Nov. 28, Dec. 3, 1994, Feb. 2, 1995, Aug. 1, Sept. 20, Oct. 1 and 7, 1996 and by the accident reports of inventor. As enclosures of this Patent Application these documents is submitted to the Patent Office. Most of the vehicles involved in the accident in these examples are German cars with the world-wide reputation offering for the best survival chance, which have always achieved good to best verdicts in the front crash tests. Volvo enjoys this reputation too. Disengagement of clamping means has always ended up, very deplorably, in fatal injuries of passengers after being

- ejected from (hurled out of) those vehicles or
- 35 – subjected to the intrusion of deformed vehicle doors. Despite the use of crowbar and welding burner to forcefully open the driver door, which was overstressed, hence, *clamped* with the passenger compartment (cell), for the purpose of first aid, all help for the driver was too late.

The following problem cases

- 40 I. large tolerances due to manufacturing and assembly,
 - II. analogy,
 - III. load cases according to Technical Mechanics in real front and side collision and
 - IV. wrong assumption idealized (specified) for the load case of the prior art
- substantiate the release of free connection of clamping means of door locks and impact elements, as noted hereinafter:

Problem case I: Recently in automotive industry, great efforts have been made to achieve (finish) a uniform (constant), small contour clearance between the outer door-contour "abcde" of vehicle door 8, 8B and the door aperture of passenger compartment in Fig. 5. in order to minimize flow noise and, particularly, to yield an attractive design. Sales success is

determined by the overall impression of design. In the state of assembly the contour clearance e.g. of AUDI ® vehicles is only 2.5 mm.

For the purpose of automatic assembly under the above-mentioned goal, a device ref. to DE 3726292 C1 determining six reference points on the outer door-contour calculates the differences between the outer door-contour and the door aperture of passenger compartment in Fig. 18 by assembly, disassembly and assembly of the same vehicle door.

Due to the small distances of overlaying coils denoted as $w \leq 0.2$ mm in Fig. 11, noises such as rattle etc. ref. to /3/ occur at different oscillations when driving. This condition is comparable with the distances of clamping parts to each other.

DE 3103580 A1 as improvement on US Pat. Nr. 3819228 is chosen among the prior art to illustrate this problem case. Three clamping bolts are bolted to an impact element fastened alongside in the door cavity (see definition). These parts should be in form-locking connection to the respective U-shaped clamping plates. After adjustment by means of the device ref. to DE 3726292 C1 or present method of hand and hammer finish to achieve a uniform, small contour clearance, the difference of each clamping bolt between the actual and true position in reference to the global xyz coordinate system is **not** calculated. The true position of each clamping plate is *unchanged*. In order to avoid expensive reworking and customer complaints due to disturbing noises /3/ large tolerances or adjustment means ref. to DE 4342038 A1 and the undermentioned features (proposals) are necessary.

Problem case II: As exemplified in Fig. 11, 12, /1/, /2/ and /5/, both end coils of compression-coil spring 19 are innerly guided by two spring seats 19.1. Their utmost outer nodes KN_1 and KN_{Ende} (not drawn) rest against both stops 19.3, where i represents the number of coils. Such guide embodiment corresponds to form-locking connection. To survey the rolling behaviour of end coil 19 on the lower spring seat 19.1 the end coil is idealized in elements by supporting springs in reference to the nodes and by the threshold value of the distance in the "state of rolling" $s < 0.1$ mm. Fig. 12, /1/ and /2/ illustrate the rolling behaviour in regard to the FEM data and test data marked with M in dependence on $F_z = -790, -1000$ and 3000 N:

– According to test data KN_2 to KN_5 roll on the spring seat at $F_z = -790$ N, but in the state of disengagement at $F_z = -1000$ and -3000 N.

– According to FEM data the nodes in the following states are in dependence on F_z :

F_z	State of contact	State of rolling
-108	KN_1, KN_{15}, KN_{17}	$KN_1 - KN_3, KN_{10} - KN_{18}$
-250	KN_1, KN_{19}, KN_{20}	$KN_1, KN_{15} - KN_{23}$
-1415	$KN_1, KN_{17}, KN_{19}, KN_{20},$ $KN_{30}, KN_{31}, KN_{33}, KN_{34}$	$KN_1, KN_{15} - KN_{35}$

Some of the clamping means in free connection are disengaged from each other on increase of impact energy. This is comparable with the disconnection of some elements of both end coils from the spring seats due to resilient property while the end coils roll thereon.

Problem case III: In order to idealize a vehicle in the undermentioned load cases the following assumptions must be specified:

– let the front impact force $2F$ along the centre line of the car replace the uniform loading due to the impact energy.

– let the structure of vehicle be replaced by two symmetric vehicle sides.

Load case I in z-y plane in Fig. 5: The moment $M_x = H \cdot h$ about the x-axis is replaced by a pair of forces $H_A = (H \cdot h)/l$ with the lever arm of l . Employing the equilibrium condition for moments two forces of reaction are obtained: $V_A = (V \cdot l_C)/l$ and $V_B = -V_A + V$. Acting in z-direction with respect to the sign are three shear forces: $-V$, $(H_A + V_A)$ and $-(H_A + V_B)$.

These forces exert bending moment along the y-axis imposed on the vehicle side comprising all post sections, series-connected doors 8, 8B with impact elements and clamping means of those doors and post sections

Load case II in z-x plane in Fig. 6: The force V exerts bending moment M_{zx} along the x-axis and rotating moment $M_y = V \cdot b$ about the y-axis acts as torsional moment along the vehicle side.

Load case III in x-y plane in Fig. 7: The A-post section is under load of rotating moment $M_{xy} = -H \cdot b$. The vehicle side is subjected to bending moment M_{xy} along the y-axis and buckling force H.

Subjected to the total stress of bending moments M_{zx} , M_{xy} , M_{zy} , buckling force H and torsional moments M_z , M_y in the load cases I to III the vehicle side in Fig. 8 is deformed in real front collision.

By reversibly positioning the series-connected doors 8, 8B the same load cases are valid for real rear collision.

Load case IV in x-y plane in Fig. 9: Under load of side impact energy S at impact angle α 27° according to FMVSS 214 or in the event of real side collision the vehicle side is subjected to bending moment M_{xys} along the y-axis and lateral force S_y .

Load case V in z-x plane in Fig. 10: Under load of side impact energy S at impact angle γ or in the real side collision against a highway column or tree the vehicle side is subjected to bending moment M_{zxs} along the z-axis and lateral force S_z .

The total stress consists of the stresses in load cases IV and V.

Problem case IV: Among the four collision types U1 to U4 in Fig. 13 ref. to the research work "Vehicle Safety in 1990s" issued by Technical Vehicle Office (Büro für Kfz-Technik) in Munich (German NHSTA, both offices work together) the collision type U2 shows the highest percentage of severe and fatal injuries in side collision at the range of impact angle $0^\circ < \alpha < 90^\circ$ against the driver door, as illustrated in Fig. 9.

With the exception of DE 4342038 A1, the release of free connection of clamping means of prior art is attributed to the following assumption for the ideal load case:

- let the centre of vehicle door be subjected to side impact energy S with impact angles $\gamma = 0^\circ$ and $\alpha = 0^\circ$ in Fig. 1, 1A, 1B and
- let free connection be valid for form-locking connection.

Such assumption for any side collision is illusory due to the negligence of the following loads and free connection:

According to the load cases IV and V the connection region roof / door frame is subjected to lateral force F_o , and the driver door to lateral forces S_y , S_z , and bending moments M_{xys} , M_{zxs} , thus resulting in the release of free connection and intrusion of driver door of the vehicle involved in the accident, as noted hereinabove.

The free connection was released by the impact when the side rail of a two-seater new expensive model collided against a column 22 of the central barrier in Fig. 13, thus resulting in the door detachment (see definition) and, later on, in ejecting the passengers from the passenger compartment during the rollover of the vehicle.

In a crash test corresponding to collision type U1 in Fig. 13 ref. to ADAC 10/1996 the collision of the very high bumper of a sport-utility vehicle (jeep) against the vehicle side of a test vehicle results in gaps between each deformed vehicle door and the respective door aperture of passenger compartment and in collapse of the B-post section.

Due to the wrong assumption and large tolerances resulting in the release of free connection of all present clamping means ref. to EP 0642940 A1, EP 0423465 A1, US Pat. Nr. 3819228, DE-OS 2162071 etc. countermeasures in Chap. D, I and J are required to increase the passenger protection.

As exemplified by US Pat. Nr. 3819228, the overall stylish impression spoiled by a *bulky clamping bolt projecting through the inner panel and passenger compartment*, will, doubtless, not be beneficial to sales. When stepping in or out of the passenger compartment while cleaning or repairing, the passenger can injury himself by stumbling over this *bulky clamping bolt*.

When closing the door the danger of damage to clothing and injury to passengers, particularly when it is dark, is apparent

See problem case IV and countermeasures in Chap. G, H and J.

In side collision in Fig. 1, 1A and 1B the clamping means ref. to DE-OS 2162071 comprising contour tongues 16.1 and contour grooves 16.2 should be in form-locking connection in order to clamp the vehicle door with side rail 18, vehicle roof 17 in Fig. 1A and B-post section. Closing or opening of the door would be possible if the outer door-contour "abcde" were square. Regarding the recent contour design in Fig. 5 and 18 the line "ab" is curve-shaped, line "bc" of front door inclined ($\beta > 90^\circ$) or spatially curve-shaped and line "bc" of rear door spatially S-shaped. Such contour design makes it impossible to close the door because the contour grooves 16.2 cant against the contour tongues.

In order to sustain large impact energy the contour groove must be reinforced by an element which, unfortunately, cannot be attached to the narrow upper window frame.

See problem case IV and countermeasures in Chap. H and J.

Ref. to EP 0659601 A1 an arbitrary L-shaped reinforcing element with a clamping hook and clamping aperture is vertically fastened to the side panel of the first cargo door. In side collision the clamping hook engages with the clamping hole of the side rail and the clamping striker of the second cargo door with the clamping aperture of the first cargo door, similar to EP 0423465 A1 in Fig. 1B. Contrary to EP 0423465 A1, DE 4342038 A1 and the feature of window-guide elements with clamping parts:

- the *vertically* reinforcing element does not increase the bending stiffness of the vehicle in longitudinal direction,
- the hook as Achilles' heel and the other clamping means *cannot* resist the lateral load in side collision.

Ref. to EP 0642940 A1 a catching hook fastened to the reinforcing element of vehicle door should clamp with the clamping hole of the B-post section if that element is deformed in side collision. See problem case IV and countermeasures in Chap. J.

Ref. to DE 4342038 A1 the clamping means 2.1 are arranged to both impact beams 1, 7, or 1B, 7B and the respective post section and clamping means 5.6 to the frames 5.1, 5.2 of both hinges in Fig. 15. In arbitrary collision (front-, rear-, side collision and/or rollover) all vehicle doors are always in engagement with all post sections by interlock of clamping means adjustable from outside via locking pieces and/or blocking and/or by inter-clamping thereof via permissible tolerances, thus increasing the stiffness of vehicle as well as lowering the stress. See shortcomings in Chap. I.

The tests for passenger protection are permanently becoming stricter and more comprehensive by FMVSS 214, EU-side crash test and the EU front crash test. In the 1st step of the EU front crash test the vehicle is crashed at 50 km/h against a 100% offset-barrier with an impact area having a 30° inclination and two vertical bars for anti-gliding thereof and in the 2nd step valid from the beginning of Oct. 98 the vehicle is crashed at 55 km/h against a deformable 40% offset-barrier.

Ref. to ADAC 9/1995 different states of deformation are reproduced in three crash tests of the involving vehicles of the same type crashed against

- a very stiff barrier,
- a deformable barrier and

5 - another vehicle of the same type

because the uniform load, deformable property of two colliding masses, impact condition etc. are different.

10 In the both letters of Feb. 2, 1995 and March 16, 1996 to the inquiries of the inventor and the examination of the clamping means ref. to DE 4342038 A1 the Technical Vehicle Office has confirmed the ejection of the passengers from the passenger compartment due to the deficiencies of the conventional clamping means of the doors and the necessities to improve the boundary condition on the clamping means and door in order to preserve the door interlock and to distribute the impact energy.

15 SUMMARY OF THE INVENTION

Accordingly, the principle object of the present invention is to overcome the deficiencies of the prior art by providing form-locking connection for clamping means having large tolerances, which are necessary in car manufacturing and door assembly, in order to
20 increase the vehicular stiffness and protect passengers against ejection from the passenger compartment in the event of arbitrary collision. These clamping means are arranged to the corresponding compound pairs.

25 In order to formulate in single terminology a generalized definition for the proper term is presented:

Definition:	Proper Term:
"all series-connected doors"	one or arbitrary all series-connected doors of each vehicle side
"girder"	panel, shell, beam etc. according to FEM and Technical Mechanics
"window-guide elements" of vehicle doors	window guides 6, 6B, 6.1, 6.2, 6.1B, 6.2B, 6.1a, 6.2a, 6.1aB, 6.2aB
"door cavity"	space between the outer and inner panel of the door
"door detachment"	vehicle door is self detached from the passenger compartment
"clamping hole"	clamping aperture, clamping slot, clamping oblong hole
"compound pair"	two vehicle parts in connection in a collision such as vehicle door / vehicle roof, vehicle door / side rail, vehicle door / post section(s), vehicle door / vehicle door, vehicle door / passenger compartment (cell)

This principle and other objects of the present invention are accomplished by the following features (proposals):

- 30 - form-locking connection by installing and adjusting clamping parts from outside to permissible tolerances (clearances) to guarantee the door interlock and inter-clamping of clamping means thereby ensuring the connection of the series-connected doors with all

post sections, vehicle roof 17, vehicle frame fastened to two side rails 18 facing each other and passenger compartment 21 in arbitrary collision;

- clamping means with adjusting means such as clamping holes / clamping blocks 15.1 to 15.5a, 15.7, 15.8, clamping hooks 15.6 / reinforcing rod 17.1d and clamping holes / clamping blocks 30 to 37 in Fig. 1, 3, 3A, 4, 4A and 14 to 18;
- window-guide elements to accommodate the clamping parts;
- space-saving, inexpensive design for clamping parts;
- arrangement of clamping parts in at least two operating planes of a compound pair;
- arrangement of clamping hole in a vehicle part for the purpose of force-locking accommodation of clamping block therein and
- U-shaped block to force-locking connect the clamping parts with the respective clamping parts of vehicle doors in juxtaposition.

Despite the failure of the prior art in the event of real arbitrary side collision any modification and extra design for survival chance in real arbitrary collision will generate costs, R&D expenses and weight due to the use of other inventions.

Summary of the advantages of the present invention:

A) saving labour-time by installing and adjusting clamping parts from outside the passenger compartment.

B) low reject rate.

C) space-saving, inexpensive design.

D) different operating planes for each compound pair to optimize the inter-engagement and inter-clamping of its clamping means in association with energy absorption in different load cases. Fig. 14 to 18 illustrate a single compound pair: window-guide element / B-post section with the clamping means: clamping blocks 34 / clamping holes in z-x plane acting as the first operating plane, however, clamping means: clamping blocks 32, 33 / clamping holes in z-y plane acting as the second operating plane. The permissible tolerances may be specified from "narrow" to "less narrow", thus cutting costs for the adjustment work. This feature of different operating planes is applicable too for both clamping means: clamping holes / 15.1, 15.2a and 15.2, 15.3 and 15.4a, 15.5 etc. in Fig. 3. A row of the same clamping blocks is operative in different operating planes by arranging a number of the same clamping blocks 15.1 to the spatially inclined A-post section or of blocks 33 to the spatially inclined B-post section. In reference to the global xyz coordinate system the clamping block 15.2a / clamping hole is operative in an inclined plane.

Because the hinge bolts of the front and rear doors have an operating direction in z-axis the arrangement of clamping means: clamping holes / blocks 31, 36 to one operating plane is sufficient. However, any additional arrangement of clamping holes / blocks 30, 35 improves the door interlock and substantially decreases fatal injuries in any real collision.

E) minimizing the R&D work by reducing FEM calculations, crash tests and by saving material due to the arrangement of clamping means in different operating planes.

F) passenger protection for all collisions by a single construction, manufacturing, testing expenditure, assembly and material supply.

G) exploitation of the transition regions of passenger compartment 21 provided with isolation material 21.10 in Fig. 17, 18 due to the sites to accommodate clamping parts and the continuous stress curve. The enlargement of the transition regions to a limited extent neither impairs the overall stylish impression nor obstructs the passenger from ingress to or egress from the passenger compartment. Those regions of all post sections are defined by the dotted lines "a1", "b1", "b2" and "c1".

H) overall stylish impression. As substitutes of the bulky clamping bolt ref. to US Pat. Nr 3819228 small clamping parts are inconspicuous, therefore making it possible to spread them out along the window-guide elements, thus lowering the stress. Due to this feature it is possible to arrange the clamping parts

5 - 30, 32, 35, 37 to the respective transition regions of passenger compartment 21.

Contrary to US Pat. Nr. 3819228 this feature won't endanger passenger when stepping in or out, furthermore, useful for passenger protection in side collision, particularly, according to collision types U1 and U2 in Fig. 13 as well as in front collision.

10 - 15.2a, 15.2, 15.7 e.g. with screws M4 to the narrow window-guide element 6.3, 6.3B of upper door frame 8.15 to resolve the problem of the large, stiff contour groove ref. to DE-OS 2162071.

15 - 33, 34, 36 to the respective window-guide elements 6, 6B and auxiliary parts 6.7, 6.8 in engagement with the reinforced B-post section without obstructing the operation of the seat belt 26.1 in Fig. 15. The fact, that no contact is made during the opening operation of series-connected vehicle doors, is demonstrated by the trajectories of both outer points of the washer and of the door edges drawn with dotted lines.

15 - 31 to the respective window-guide elements 6 and auxiliary parts 6.6a in engagement with the reinforced A-post section.

20 I) less stress to solve the problem of total deformation. By means of arrangement of clamping means in multi-operating planes and increase of compound pairs such as vehicle door / vehicle roof 17, vehicle door / side rail 18, vehicle door / post section(s) and vehicle door / passenger compartment 21 more vehicle parts in compound construction are involved in energy absorption in different load cases in the event of arbitrary collision.

25 In conjunction with DE 4342038 A1 the structural stiffness reaches the maximum. Beyond doubt, the advantage of clamping means 2.1, 5.6 / clamping holes is due to the further exploitation of the very stiff impact beams 1, 7 to house the clamping parts. Because the other compound pairs such as vehicle door / side rail and vehicle door / vehicle roof are not equipped with clamping means this *single* arrangement of one compound pair in mid region is insufficient in the event of real arbitrary collision, therefore endangering the passengers in the following state of deformation

30 - intrusion of vehicle roof into the passenger compartment and of the upper door frame 8.15, thus squashing the passengers and

35 - buckling of the upper portion of the A-post section, total deformation of the upper door frame, buckling of vehicle roof 17 and buckling of side rails 18 in Fig. 8.

In order to avoid the above-mentioned state a number of clamping holes / clamping blocks 30 to 37 is arranged in the regions *above, below* of the impact beams 1, 7 and *therebetween* by eliminating those clamping means 2.1, 5.6.

40 When the *non-adjustable* clamping parts 5.6 of the door hinges in x-z operating plane are replaced by a number of clamping means 15.1, 15.2a, 15.4, 30, 31 in several operating planes, the total stress of the compound pairs: A-post section / vehicle door along the z-axis is uniform and lower due to stress distribution, thereby preventing to a certain extent the A-post section and vehicle door from total deformation in Fig. 8.

J) protection the passengers against ejection from the vehicle involved in the accident and against total deformation of the vehicle. During the deformation of the B-post section and side rails, when the driver door is not deformed (problem case IV), the *large* tolerances allow the release of the following clamping parts attached to the B-post section and side rail, such as open U-shaped plates 98, 58 ref. to DE 3103580 A1 (US Pat. Nr. 118535), round clamping parts 4b, 7 and clamping plates 18 ref. to US Pat. Nr. 3819228, apertures 10 ref. to EP 0642940 A1, slots ref. to EP 0423465 A1 and contour grooves 16.2 ref. to DE-OS 2162071 representing the prior art, thus detaching door, overstressing vehicle parts and ejecting the passengers from the vehicle during the rollover of the vehicle. This can solely be avoided by *inter-clamping* of the following clamping means governed by the permissible tolerances:

- clamping holes / clamping blocks 15.3, 15.3a, 15.5a, 15.5 thanks to the U-shaped blocks 17.3, 18.3, whose deformation causes a constrained deformation of the juxtaposed vehicle doors, vehicle roof and side rails,
- clamping holes / clamping blocks 32, 33, 34, 30, 15.4, 15.4a thanks to force-locking accommodation of the clamping blocks in the clamping holes and arrangement of the pairs in different operating planes (Chap. D); *and/or*
- clamping hooks 15.6 / reinforcing rod 17.1d for both compound pairs such as juxtaposed vehicle doors / side rail and juxtaposed vehicle doors / vehicle roof, so that the deformation of the side rail and vehicle roof causes a constrained deformation of the juxtaposed vehicle doors; and

by *force transmission* into the other vehicle side by means of transverse girders 17.2, 17.2b, 17.2c, 17.2d, 18.2 of vehicle roof and side rails, thus force-locking connecting all post sections facing each other. Fatal injuries and total deformation in any real collision are minimized by the energy distribution and the increase of energy absorption.

K) passenger protection by door interlock in rear collision. Detachment of rear door and driver door in rear collision occurs due to the lack of door hinges and inter-clamping of clamping parts of doors and post sections. For the purpose of door interlock the properties of force transmission and of inter-clamping of clamping parts are improved by the connection of rear door 8B with the C-post section in association with the attachment of

- auxiliary part 6.5C, adapted to the outer door-contour to the parts of rear door, having clamping holes to engage with clamping blocks 37 in Fig. 14, 18 and
- clamping blocks 33, 34 to window-guide element 6B.

The features of vehicle door for inter-engagement are, doubtless, suitable for tailgate door, sliding side door, cargo door, *arbitrary* series-connected doors and post sections, e.g. *three* vehicle doors with *four* post sections of large van. In the real side collision aforementioned the tailgate door was totally deformed.

BRIEF DESCRIPTION OF THE DRAWINGS

A number of embodiments, other advantages and features of the present invention will be described in the accompanying drawings with reference to the xyz global coordinate system.:

Fig. 1 is a side view of vehicle side, impact beams, clamping blocks, clamping hooks, window guides and window-guide elements (reinforcing elements).

Fig. 1A is a cross-sectional view of a vehicle door engaging with a roof and side rail ref. to DE-OS 2162071 in side collision.

Fig. 1B is a cross-sectional view of a vehicle door engaging with a side rail ref. to EP 0423465 A1 in side collision.

Fig. 2 is a side view of a U-shaped window-guide element, the position of clamping blocks 15.7, 15.8 and of an additional window-guide element 6.4, 6.4B.

Fig. 2A is a side view of a U-shaped window-guide element, the position of clamping blocks 15.7.

Fig. 3 is a perspective view of a front door truss with both window guides, both respective window-guide elements and clamping means of the 1st embodiment.

Fig. 3A is a cross-sectional view of a clamping block with adjusting means.

Fig. 4 is a perspective view of clamping means clamping hooks / reinforcing rod of the 2nd embodiment.

Fig. 4A is a cross-sectional view of the clamping hook with adjusting means and of the reinforcing rod.

Fig. 5 illustrates a load case I in z-y plane in front collision of vehicle.

Fig. 6 illustrates a load case II in z-x plane in front collision.

Fig. 7 illustrates a load case III in x-y plane in front collision.

Fig. 8 is a state of total deformation of vehicle at displacement v in front collision.

Fig. 9 illustrates a load case IV in x-y plane in side collision of vehicle.

Fig. 10 illustrates a load case V in z-x plane in side collision.

Fig. 11 is a view of a compression-coil spring on a lower spring seat.

Fig. 12 illustrates the projection of the end coil and spring seat in a plane, the test data and FEM data of an end coil rolling on the lower spring seat in dependence on load.

Fig. 13 illustrates four collision types U1 to U4 ref. to the research work of Technical Vehicle Office.

Fig. 14 is a perspective view of clamping means of the 3rd embodiment comprising a front door truss having a single window-guide element and a rear door truss having a single window-guide element to engage with the post sections.

Fig. 15 is a cross-sectional view of the series-connected doors in engagement with the A-, B-post section and of the passenger compartment along the line D-D in Fig. 14.

Fig. 16 is a side view of the series-connected door trusses without window pane in engagement with the B-post section according to arrow E in Fig. 14.

Fig. 17 is a perspective view of clamping means of the 4th embodiment comprising a front door truss having a single window-guide element in engagement with the transition regions of passenger compartment.

Fig. 18 is a side view of the transition regions of passenger compartment.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In Fig. 3 the 1st embodiment consists of clamping means, whose clamping parts are attached to two window-guide elements of vehicle door and whose respective clamping parts to the A- and B-post section, vehicle roof and side rail.

In Fig. 4 the 2nd embodiment consists of a clamping means, whose clamping hooks are attached to two window-guide elements of each vehicle door and whose reinforcing rod to the vehicle roof and all post sections. The reinforcing rod serves to reinforce the vehicle roof and to aid positioning at the assembly thus cutting costs. However, this embodiment needs space, which is available in large cars, trucks and vans.

In Fig. 14 to 16 the 3rd embodiment consists of clamping means, whose clamping parts are attached to a window-guide element of each vehicle door 8, 8B and whose respective clamping parts to the A-, B-post section and respective reinforcing elements 21.3, 21.3B of transition regions of passenger compartment 21. The clamping blocks 30 to 37 / clamping holes can arbitrarily be attached to vehicle doors, post sections and passenger compartment.

After welding the reinforcing element 23 to the inner region of B-post section the clamping holes are machined.

The 4th embodiment consists of

- clamping means 30 / 6.5, 35 / 6.5B and other clamping means 32 / 6.9, 37 / 6.9B (6.9, 6.9B similar to 6.5) in Fig. 17,
- transition regions of passenger compartment 21 and the enlarged transition regions defined by the dotted lines "a1", "b1", "b2" and "c1" along the post sections to house the clamping blocks 30, 32, 35, 37 in Fig. 18 and
- two compound pairs such as transition regions of passenger compartment 21 / window-guide element 6 of front door 8 and transition regions of passenger compartment 21 / window-guide element 6B of rear door 8B.

The clamping blocks 30, 32, 35, 37 are rigidly attached to the respective reinforcing elements 21.1 to 21.5, 21.1B to 21.5B of transition regions of passenger compartment 21. The welding of reinforcing elements to the transition regions opposite the vehicle doors has the advantage of using only a single element such as 21.4, 21.1B. Those elements can be arranged between both panels of passenger compartment. The reinforcing element 21.5B is welded to the transition region and rear wheel case. The same reinforcing method can be employed to arrange a similar element 21.1 in the transition region and to the front wheel case.

According to the description of DE 4342038 A1 a door truss of vehicle door can be assembled, without door girder and reinforcing elements, from at least two impact beams provided with clamping means and at least one window-guide element 6, 6B, 6.1, 6.2, 6.1B, 6.2B, 6.1a, 6.2a, 6.1aB, 6.2aB. As is customary, the window guides 6.1, 6.2, 6.1B, 6.2B in Fig. 1 and 3 are made from U-shaped thin panel. As *reinforcing elements* the window-guide elements are of higher-grade tensile strength 6.1a, 6.2a, 6.1aB, 6.2aB to:

- reinforce the U-shaped window guides of metal sheets,
- receive clamping parts such as clamping hooks, clamping blocks and/or clamping holes (apertures) and
- receive auxiliary parts 6.5, 6.5B, 6.6a, 6.6b, 6.7a, 6.7b, 6.8, 6.9 (not drawn) as structural element with higher-grade tensile strength.

The following auxiliary parts are fixedly attached

- 6.8, 6.9 to the front faces of both impact beams 1B, 7B and window-guide element 6B,
- 6.6b, 6.7b to window-guide element 6 and impact beams 7 and
- 6.6a, 6.7a between both impact beams 1, 7 and window-guide element 6.

Both window-guide elements are replaceable by a U-shaped stiff window-guide element 6, 6B in Fig. 2, 2A, 14 to 17. Less stiff elements 6.3, 6.3B are normally made of panel. Alternately, very stiff window-guide element 6.3, 6.3B serves to receive the window pane and clamping blocks 15.7.

Window-guide element 6, 6B provided with window-guide element 6.3, 6.3B in the door cavity in Fig. 2A have open ends. To maximize the stiffness of window-guide element 6, 6B both ends are force-locking connected with each other by window-guide element 6.4, 6.4B in the door cavity in Fig. 2, 14 to 17:

- after the window pane has been inserted, *or*
- by having flat profile in Fig. 14, 15, 17 for the purpose of receiving window pane 60, 60B in Fig. 15. Later on, this window pane must be supported against falling down by securing parts.

The window-guide element 6.4, 6.4B is useful for accommodation of clamping parts 15.8. If extraneous weight is not that important for heavy cars, trucks and vans, the following goals for independent parts are applicable:

- the window-guide element fastened to the impact beams as reinforced door frame to receive clamping parts and
- the window guides of panel to guide and receive the window pane.

To clamp with the respective clamping parts the following clamping parts are attached:

- 15.1, 15.2, 15.2a, 15.3, 15.3a, 15.4, 15.4a, 15.5 and 15.5a along the vehicle roof, side rail and post sections,
- 15.3, 15.3a and/or 15.5, 15.5a to the *common* post section of the juxtaposed vehicle doors e.g. *B- and C- post section* of 6-door vans,
- 30 and 31 to the A-post section,
- 33, 34, 35 and 36 to the *common* post section of the juxtaposed vehicle doors,
- 33 and 34 to the C-post section,
- 15.7 replaced by at least one clamping block 15.2, 15.2a, 15.4, 15.4a, 30 to 37 along the vehicle roof,
- 15.8 replaced by at least one clamping block 15.2, 15.2a, 15.4, 15.4a, 30 to 37 along the side rail.

By means of this design clamping blocks 15.1 can arbitrarily be attached to the post section having door hinges.

In the following embodiments in Fig. 3, 4, 14 to 18 the connection of all series-connected doors with vehicle roof 17, passenger compartment 21, vehicle frame fastened to two side rails 18 facing each other and with the respective post sections in any collision is ensured by perfect engagement of the following clamping blocks 15.1 to 15.5a, 30 to 37 with clamping holes (clamping apertures) and/or of the following clamping hooks 15.6 with reinforcing rod 17.1d:

- clamping block 15.1, bolted to a reinforcing element of the L-shaped A-post section, with the clamping oblong hole of window-guide element 6.1a. This A-post section is welded to reinforcing panel 17.1c disposed along the vehicle roof and to transverse girder 17.2d of both facing A-post sections of both vehicle sides. This feature is applicable for window-guide element 6.2a, 6.1aB, 6.2aB in association with the B- or C-post section.
- clamping block 15.2a, bolted to block 6.11 of window-guide element 6.1a, with the clamping oblong hole of reinforcing panel 17.1 disposed along the vehicle roof. This panel is welded to reinforcing plate 17.2a of the L-shaped A-post section and to transverse girders 17.2, 17.2b of both facing A-post sections. To cut costs the reinforcing plate 17.2a can act as transverse girder by eliminating parts 17.2, 17.2b. These features are applicable for window-guide element 6.2a, 6.1aB, 6.2aB in association with the B- or C-post section.
- clamping block 15.2, bolted to window-guide element 6.2a, with the clamping hole of reinforcing panel 17.1a disposed along the vehicle roof. This feature is applicable for engagement of clamping block 15.2 bolted to window-guide element 6.1a, 6.1aB, 6.2aB with the clamping hole.
- clamping block 15.3 and clamping block 15.3a, bolted to the legs of U-shaped block 17.3, with the clamping apertures of window-guide elements 6.2a, 6.1aB. As connection element between the B-post section and the vehicle roof this U-shaped block in the B-post section is welded to reinforcing panel 17.1b disposed along the vehicle roof and to transverse girder 17.2c of both facing B-post sections of both vehicle sides.

- clamping block 15.4, bolted to the reinforcing plate of reinforcing panel 18.1 disposed along the side rail, with the clamping hole of window-guide element 6.1a. This feature is applicable for window-guide elements 6.2a, 6.1aB, 6.2aB.
- clamping block 15.4a such as pin e.g. ref. to DIN660, fastened to the reinforcing plate of reinforcing panel 18.1a disposed along the side rail, with the clamping hole of window-guide element 6.2a.
- clamping block 15.2a in x-y operating plane as substitute for clamping block 15.4, 15.4a or 15.8.
- clamping block 15.5 and clamping block 15.5a, bolted to the legs of U-shaped block 18.3, with the clamping apertures of window-guide elements 6.2a, 6.1aB. As connection element between the B-post section and the vehicle frame this U-shaped block in the B-post section is welded to reinforcing panel 18.1b disposed along the vehicle frame and to transverse girder 18.2 of both facing B-post sections of both vehicle sides. The belt case 26 can be housed in U-shaped block 18.3.
- clamping hooks 15.6, bolted to window-guide elements 6.1a, 6.2a, 6.1aB, 6.2aB, with the reinforcing rod 17.1d disposed along the vehicle roof or side rail in Fig. 4. This rod is welded to transverse girders 17.2e, 17.2f, 17.2g of both A-, B- and C-post sections.
- clamping blocks 30, 32, 35, 37, bolted to the respective reinforcing elements 21.3, 21.5, 21.3B, 21.5B of the bottom transition regions of passenger compartment 21 in Fig. 14 to 18, with the corresponding clamping holes of auxiliary parts 6.5, 6.5B which are rigidly attached to the respective window-guide elements 6, 6B and the respective auxiliary parts 6.6b, 6.7b, 6.8, 6.9 (not drawn due to similarity to 6.7b).
- clamping blocks 30, 32, 35, 37, bolted to the respective reinforcing elements 21.1, 21.4, 21.1B, 21.4B of the top transition regions of passenger compartment 21, with the corresponding clamping holes of auxiliary parts 6.5, 6.5B which are rigidly attached to the respective window-guide elements 6, 6B.
- clamping blocks 30, 35, bolted to the respective reinforcing elements 21.2, 21.2B, which at halfway up location are fixed to the post-section-transition regions of passenger compartment 21, with the corresponding clamping holes of auxiliary parts 6.5, 6.5B which are rigidly attached to the respective window-guide elements 6, 6B and the respective impact beams 1, 1B.
- clamping blocks 31, bolted to auxiliary part 6.6a of window-guide element 6, with the clamping holes of (machined in) the reinforced A-post section in Fig. 14 to 16.
- clamping blocks 36, bolted to auxiliary part 6.8 of window-guide element 6B, with the respective clamping holes of the B-post section reinforced by reinforcing element 23.
- clamping blocks 33, bolted to window-guide element 6, with the respective clamping holes in the reinforced B-post section. Similarly, the clamping blocks 33 can be attached to window-guide element 6B and the respective clamping holes of the reinforced C-post section. In Fig. 16 a washer 15.13 with radial teeth serves as part of clamping block 33 to improve the clamping with the inner region of the reinforced B-post section in arbitrary collision. As an integral part of a screw ref. to DIN 931 Form Z the washer won't become loose on assembly.
- clamping blocks 34, bolted to auxiliary part 6.7a of window-guide element 6, with the respective clamping holes of the reinforced B-post section. Similarly, the clamping blocks 3e can be attached to auxiliary part 6.9 of window-guide element 6B and the respective clamping holes of the reinforced C-post section.

It is possible to arrange

- several pairs of clamping blocks 15.3, 15.5 to the legs of U-shaped block 17.3, 18.3 and
- several clamping blocks 30, 32, 35, 37 with the same feature in the enlarged transition regions of passenger compartment 21 defined by the dotted lines "a1", "b1", "b2" and "c1" in Fig. 18.

By applying the associative rule for the arrangement of each clamping means the attachment of clamping block and hole to the corresponding parts is reversible.

By welding a reinforcing plate to the surface of the site of clamping part a structural reinforcement is achieved. If extraneous weight is insignificant for heavy vehicle like truck or van, replace reinforcing panel by beam or beam-rod.

Costs can be cut by using mechanical connecting parts, particularly standard parts like washer ref. to DIN125, hexagon socket head screw ref. to DIN912 etc. This is exemplified by clamping block 15.4a as rivet ref. to DIN660. With the exception of 15.4a each clamping block 15.1 to 15.5a, 30 to 37 comprises a screw 15.14, a sleeve 15.11, a number of washers built into one spacer 15.12 and a washer with a large exterior diameter 15.13 illustrated in Fig. 3A, 14 to 18.

Due to bigger clearances the most inexpensive clamping block 15.4a in association with the other clamping blocks 15.1 to 15.5a is suited for engagement with the respective clamping holes. However, for perfect inter-engagement at low cost by limited use of the clamping means, the provision with clamping blocks 15.1 to 15.8, 30 to 37 without clamping block 15.4a is ultimately necessary.

In order to ensure perfect inter-engagement between clamping block and clamping hole (aperture) a small tolerance zone in Fig. 3A, 14 to 18 must be preserved by:

- assembling a sleeve with exterior diameter D chosen from the stock of the sleeves with different exterior diameters; and/or
- correcting the length of spacer l by removing or adding several washers.

Each clamping hook 15.6 in Fig. 4 and 4A comprises a hook 15.20 with interior diameter d_1 and gap s_1 smaller than d_1 , a screw 15.21, a number of washers built into one spacer 15.22, a coil-spring washer 15.24 and a nut 15.25. The symbols s_1 , d_1 and d_2 are indicated in Fig. 4A. In order to ensure perfect inter-engagement between the clamping hooks and reinforcing rod 17.1d with diameter d_2 smaller than s_1 a small tolerance zone in Fig. 4A must be preserved by:

- assembling a hook with gap s_1 chosen from the stock of the hooks with different gaps;
- assembling a rod with diameter d_2 chosen from the stock of the reinforcing rods with different diameters;
- correcting the distance l_1 by removing or adding several washers of spacer; and/or
- positioning the centres of the hook hole and the reinforcing rod out of alignment.

Although the present invention has been described and illustrated in detail, it is clearly understood that the terminology used is intended to describe rather than limit. Many more objects, embodiments, features and variations of the present invention are possible in light of the above-mentioned teachings. Therefore, within the spirit and scope of the appended claims, the present invention may be practised otherwise than as specifically described and illustrated.